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Scientometric research of the migration waves of Ukrainian scientists at the beginning of the XXI century

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ABSTRACT

The article contains the results of a scientometric assessment of the current state of scientific migration processes in Ukraine. Their features and main trends were identified, methodical approaches to their fixation and consolidation of the obtained data in national bibliometric systems were formed using methods of source studies and analysis of scientific publications on the researched topic, as well as methods of statistical, comparative and structural analysis. The sources of data for the research were the international multi-subject databases of scientific publications, Web of Science, Scopus, as well as the multidisciplinary registrar of unique scientific identifiers ORCID, the Scopus SCImago Journal & Country Rank indicator (for evaluating the scientific weight of publications) and the information-analytical system "Bibliometrics of Ukrainian science". The authors found that the phenomenon of scientific migration is constantly present in all periods of Ukraine's existence, and one of its consequences is the decline of the country's intellectual potential, marked by the deterioration of scientometric indicators of the activity of domestic science. At the same time, the positive consequences of intellectual migration have also been recorded, in particular, the conduct of scientific research in the conditions of emigration, which could not be carried out in the scientist's homeland, the increase in the knowledge of Ukrainian scientists and their demand, stimulation of the development of science in general. When analyzing the functionality of bibliometric and scientometric databases for monitoring changes in the affiliations of domestic scientists, the advantages of the ORCID registry as a source database for conducting scientometric studies of migration processes were revealed. The concept of a general approach to recording and evaluating the phenomenon of scientific migration of domestic scientists by national bibliometric systems is proposed, which should involve a combination of the citation-numerological scientometric approach with expert conclusions.

KEYWORDS

scientific migration, bibliometric and scientometric research, bibliometric technologies, migration processes in Ukraine

Introduction

The problem of migration, in particular the loss of scientific potential due to migration of scientists, is not new for Ukraine. Large-scale waves of scientific migration were observed at the beginning of the first decades of the last century, resumed in the 90s and significantly accelerated due to the Russian armed aggression in 2014. The reasons for scientific migration processes were social, economic, and political factors (wars, revolutionary upheavals, a sharp decrease in research funding, etc.), in particular, the decline in the status of scientists in society at the beginning of the 21st century. Armed Russian aggression significantly accelerated scientific migration processes in Ukraine, and also changed the nature of the migration waves, causing

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large-scale losses of the state's intellectual potential. Thus, if in the countries of the "collective West" the number of researchers increased by an average of 19.5% from 2013 to 2018, then in Ukraine, on the contrary, it decreased by 19.4% (*Zahorodnii, 2020*). At the same time, it is predicted that after the end of full-scale invasion, at least 10% of active scientists who worked until February 24, 2022 will not return to Ukraine (*Strikha, 2022*).

Ukraine traditionally acts as an intellectual donor in migration processes, therefore the problem of the process of migration of Ukrainian scientists to other countries in society is given considerable attention. At the same time, as noted by I. Maidanik (2021), studies of migration through the prism of time are at the initial stage. Her study of the temporal (past, present, future) aspects of migration and the form of their interconnections, based on the research of the Brazilian Sociologist S. Cwerner (*1999; 2001*), demonstrated that in order to develop a deeper understanding of migration, it is necessary to examine the intellectual outflow Ukrainians in a temporal approach (*Maidanik, 2021*). O. Blynova (*2019*) emphasized another one of the features of scientific migration - the threat to the country's intellectual security. Such a threat was also highlighted by O. Demydenko (*2019*).

Scientific migration became especially widespread in the early 1990s, when, in particular, in 1992–2008, almost 700 doctors of science and more than 1,200 candidates of science went to live abroad (*Ukrainske suspilstvo…, 2018*). O. Malynovska (*2017*), who studied aspects of migration issues in the process of European integration of Ukraine, in particular analyzed likely changes in the migration behavior of Ukrainians as a result of the deepening of European integration processes and proposed measures aimed at further improving the migration policy of Ukraine. The President of the National Academy of Sciences of Ukraine, academician A. Zahorodnyi, cited rather disappointing data about the current state of science in Ukraine:

> "The annual budget for financing 170 institutions of the Academy is the budget of one well-endowed American university; if in Poland, Germany, Great Britain and the USA the number of researchers from 2013 to 2018 increased by 44.6%, 15.8%, 9.8% and 6.4%, respectively, in Ukraine, on the contrary, it decreased by 19.4%; in 2019, 2,270 young scientists worked in scientific institutions of the National Academy of Sciences of Ukraine, which 15% less than in 2018. The number of young scientists with the degree of candidate of sciences (local PhD analog) decreased by 5%. Compared to 2013, these indicators are 32% and 24%, respectively" (*Zahorodnii, 2020*).

M. Strikha (Deputy Minister of Education and Science of Ukraine in 2008-2010, 2014-2019) analyzed the most significant migration wave that began in February 2022 in connection with full-scale Russian aggression against Ukraine. He predicted that at least 10% of active scientists who worked until February 24, 2022, will not return to Ukraine (*Strikha, 2022*). E. Libanova, O. Pozniak, O. Tsymbal's (*2022*) study paid attention to the assessment of the scope and consequences of forced external and internal migrations as a result of the active phase of the Russian-Ukrainian war. The authors considered the factors of the return of forced migrants to Ukraine, assessed the consequences of these large-scale migrations, and proposed recommendations for their regulation. In addition, it is stated that the validation of the information of the conducted assessments is possible after the population census. A. Szwed (*2022*) stated that as a result of the armed conflict in Ukraine, due to which millions of Ukrainians left the territory of their country, a more intensive use of modern technologies based on artificial intelligence is needed to control the international movement of people. The issues of migration and the use of innovative technologies related to artificial intelligence are also covered in the studies of H. Mehr (*2017*), C. Dumbrava (*2021*) and A. Beduschi (*2021*).

An important factor affecting the migration processes of Ukrainian scientists is international project support, which, in particular, allows Ukrainian scientists to continue their research in academic and non-academic organizations of EU member states and countries associated with Horizon Europe (*MSCA4Ukraine, 2024*), and supports the multi-vector development of policies for the post-war recovery of scientific activity in Ukraine and assistance to scientists who suffered from the war (*Survey of Ukrainian scientists, 2023*). According to the founders of one such project, 15% of the Ukrainian scientific infrastructure was damaged due to the full-scale invasion of Russia (Survey of Ukrainian scientists, 2023), and according to the UA survey Science Reload, of the 88.2% of scientists remaining in Ukraine, 72.9% note that they cannot continue their research to the extent that was before the full-scale invasion. Project experts point out that science in Ukraine is going through the biggest crisis of the century in the conditions of unprecedented war and humanitarian disaster (*Zinevych et al., 2023*).

However, despite the general statement of the threat of the loss of Ukraine's intellectual potential, in the current scientific literature on the subject of research on scientific migration processes, concrete and effective ways of assessing and overcoming this threat are not given. Proposals to increase spending on scientific research (see: *Zahorodnii, 2020, Demydenko, 2019; Libanova et al., 2022*) are considered unlikely in connection with the realities of the economic situation in which Ukraine is. Therefore, there are reasons to believe that insufficient study of the problem of scientific migration in general, assessment of its current state and development of a methodology for its fixation, determination of its impact on the further innovative development of Ukraine require conducting scientometric studies on this topic.

The conducted research was aimed at the scientometric assessment of the current state of scientific migration processes in Ukraine, the identification of their characteristics and main trends, the development of the basics of methodological approaches for their fixation and consolidation of the obtained data in national bibliometric systems.

Research methods

The research was conducted using the methods of source research and analysis of scientific publications on the topic under study, as well as statistical, comparative, and structural analyses. Data from Web of Science (WoS), Scopus, ORCID, SCIMago and information and analytic system "Bibliometrics of Ukrainian Science" for the period 2020-2023 (number of publications, number of citations, ratings and H-index) were used to analyze the publication activity and scientometric success of Ukrainian scientists and scientific institutions. Data of scientists of the Kyiv National University of Construction and Architecture obtained for the period 2022–2023 during the update of the "Bibliometrics of Ukrainian Science" database (routine check of changes in affiliation, H-index, names, compliance of existing links to profiles in foreign bibliometric databases) in

the third quarter of 2023 were used to assess migration processes. The comparative analysis was carried out with the help of SCIMago top ratings data.

The WoS toolkit and Microsoft applications were used for visualization and structural analysis of the obtained results Word 2010.

Results and Discussion

SCIMago (*SCIMago Journal & Country Rank, 2023a*) is a publicly available scientometric rating portal based on data from the Scopus database. The data of the specified portal for the years 2020-2023 regarding the ratings of world states and regions with data on their publication activity and quantitative indicators show that in 2022, in terms of publication activity and quantitative indicators of citations, Ukraine is in 47th place, while in 2020 and 2021 it took 41 places in this rating (*SCIMago Journal & Country Rank, 2023b*).

The evaluation of the publication activity of the National Academy of Sciences of Ukraine in the period 2021–2023 was carried out using data from the bibliometric platforms Scopus and WoS. There is an overall decline in the number of publications during the full-scale invasion compared to the reference (2021) year, as well as a progressive decline in publication activity in the second year of the full-scale invasion. The results of the study are summarized in Table 1.

Table 1. – Publication activity of the National Academy of Sciences of Ukraine in the period 2021-2023, number of publications

Database	Years		
	2023	2022	2021
Scopus	4307	5338	5688
WoS	2464	3546	3841

The assessment of the migration processes of scientists of the Kyiv National University of Construction and Architecture was carried out using the data of the Ukrainian local information and analytical system "Bibliometrics of Ukrainian Science" (BUN), which is a national segment of Google Scholar and integrates data from foreign bibliometric and scientometric platforms Google Scholar, Scopus, WoS and the ORCID registry (*Bibliometryka Ukrainskoi Nauky, 2023*). The scientific institution was chosen randomly during the periodic updating of data of this bibliometric platform by the employees of the Department of Bibliometrics and Scientometric of the Vernadsky National Library of Ukraine (VNLU). From the 495 profiles of scientists registered in BUN, according to the data that scientists submitted to the Department of Bibliometrics and Scientometric of the VNLU, and the changes they made to their profiles on the Google Scholar platform up to and including the 3rd quarter of 2023, 14 scientists of the Institute have changed affiliation to a scientific institution (including 4 cases of migration to other countries).

The results of monitoring according to personal profiles of scientists of the Kyiv National University of Construction and Architecture are shown in Figure 1.

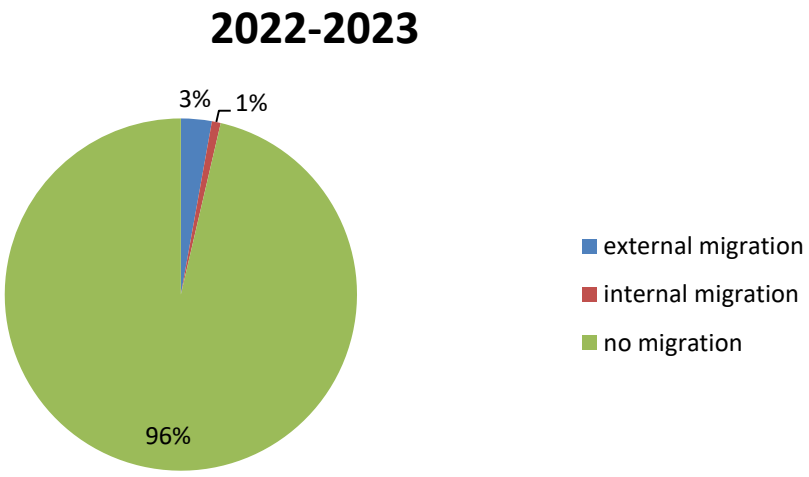

Figure1. Migration of scientists of Kyiv National University of Construction and Architecture in 2022-2023

For the period of 2022-2023, there are signs of both among scientists of the Kyiv National University of Construction and Architecture, which is probably due to the beginning of a full-scale phase of Russian aggression against Ukraine. In the structure of migration, there is a predominance of internal migration. At the same time, these data are not relevant to the full extent, because they directly depend on the timeliness and completeness of the submission of information about themselves by scientists of the

Institute. In addition, it should be noted that the functionality of the bibliometric system "Bibliometrics of Ukrainian Science" due to the lack of funding for the project lacks periodic full archiving of the state of the data with the possibility of providing chronological access to them to the average user in the future.

Among the registers of personal identifiers of researchers (profiles), the most informative and widespread are ORCID (multidisciplinary register of unique identifiers of scientists), ResearcherID (global interdisciplinary register of unique identifiers of scientists from Thomson Reuters), Scopus Author ID, Google Scholar ID. Links to these identifiers are available in most national bibliometric systems, including in the information and analytical system "Bibliometrics of Ukrainian Science", which is a national bibliometric service that has been formed since 2014 and covers data on more than 57 thousand scientists (*Bibliometryka Ukrainskoi Nauky, 2023*).

Table 2 compares the data recorded as of 2023 by various scientometric platforms. In order to obtain consolidated information about subjects and objects of scientific activity and the dynamics of their changes in time and space, it is considered appropriate to use all the above-mentioned identifiers for monitoring migration processes.

Table 2. – Research profile data from scientometric platforms

Profile of scientist	ORCID	Scopus	Web of Science	Google Scholar
Name variations	+	+	+	+
Belonging to the institution	+	+	+	+
ID number	+	+	+	+
Photo	–	–	+	+
Keywords	+	+	–	+
Bibliometric indicators	–	+	+	+
Co-authors	+	+	+	+
Compatibility	Scopus, WoS, Google Scholar	ORCID	ORCID	ORCID

Thus, ORCID should be considered the most informative of the registries. Its advantages include integration with most of the world's scientometric databases covering almost the entire global research field.

One of the disadvantages of using traditional bibliometric indicators based on publication citations in evaluation is their need for a fairly significant period of time for calculation and use. It takes one to two years, or even more, for an article to pass peer review, appear in a scientometric system, be read, and possibly referenced. Therefore, in the conditions of rapid migration processes, it is potentially appropriate to use alternative metrics that arose in response to the insufficient attention of the traditional bibliometric approach to the rapid spread of unofficial online communication platforms of scientists (social networks, media platforms, author blogs, etc.). They are characterized by the efficiency of accounting for the social effect of the results of scientific research and the popularization of scientific knowledge among a wide online audience (*Zhabin, 2016*). The symbiosis of a wide range of additional indicators of alternative measures of scientific activity and traditional bibliometric indicators, processed and summarized by specialized analytical tools, is a strong source base for independent expert evaluation of the results of research activities of scientists in the conditions of migration waves. Currently, one of the leading sources for obtaining alternative metrics is the Dimensions information system, a product of the Digital Science company (UK) – a dynamic platform for accessing related research data. Using its services, users can explore connections between publications, grants, clinical trials, patents, legislative documents and other scientific content. That is, it is possible to find and receive basic access for personal non-commercial use to the most relevant scientific information free of charge. The analytical tool of the platform allows users to collect information for the formation of future research strategy, however, using an advanced version of this platform Dimensions Plus is a paid service.

The scientometric approach to the procedure of general monitoring of the scientific migration of Ukrainian scientists assumes the following. First, the number of scientists in national scientometric systems (BUN) with an undefined place of work or already known affiliation to a foreign scientific institution is established. Then, based on the available links, data is collected from the personal profiles of scientists in the Google Scholar, Scopus, Web of Science, and ORCID databases and a contextual analysis of the personal data available in these profiles is carried out. According to the monitoring results, the number of migrant scientists is finally determined and their personal information is consolidated for further updating in the national scientometric systems. This information is a source base for the formation of a separate integrated segment of Ukrainian scientists who have become intellectual donors for other countries, and an in-depth study of the processes of intellectual migration. Among the potential users of such information are the experts of the National Academy of Sciences and the Ministry of Education and Science of Ukraine, who will prepare predictive materials for the optimization of state policy in the field of science and innovation, and all interested structures and persons for the establishment of mutual relations. It is also considered expedient to use scientometric approaches for evaluating the effectiveness of research activities to identify the most promising research within the framework of possible joint activities with migration centers. Currently, for the assessment of scientific activity, not only the quantitative approach of calculating the citation rates of scientific publications is used, but also the approach of expert assessment (*Kopanieva, 2019; Kostenko et al., 2020*), which, in particular, is based on the principles of The Leiden Manifesto for research metrics, the first of which requires supplementing the expert opinion with quantitative assessments, which

we consider a classic example of an approach to overcoming the phenomenon of dualism in scientometrics (*Hicks et al., 2015; Kostenko et al., 2016*). Expert evaluation procedures require the participation of a significant number of highly qualified specialists with an impeccable reputation and trust in the scientific community. The evaluation itself should be carried out in the environment of reference groups, which are formed according to the principle of relatedness in the fields of their scientific activity. Applications such as InCites (Clarivate Analytics) and SciVal (Elsevier) can serve as analytical tools.

Based on the analyzed research material and the results of the conducted research on the waves of outflow of scientists from Ukraine since the beginning of the 21st century and, separately, the period of the beginning of the full-scale phase of armed Russian aggression, it should be stated that the scientific migration processes were not fully investigated using the methods of the scientometric approach and the assessment of their impact on the intellectual potential of the country, and the power structures of the USSR even tried to hide the data, which were then restored by with the help of demographic studies (*Pyrozhkov, 2004*). Meanwhile, the trends of intellectual donation of the last two years demonstrate significant negative consequences both for the scientific and technical potential of our state and for its prestige in the world scientific community, causing a drop in Ukraine's place in the world scientometric ratings.

Currently, there is no significant novelty in solving the problem of "brain drain". Also, the intensification of migration processes was not accompanied by the organization of measures by the state to contain them, which is understandable - during military operations, the solution of tasks to ensure the livelihood of citizens is put in the foreground.

Scientometric studies of migration processes of scientists are complicated by the subjective factor of the timeliness of scientists making changes to their personal scientific profiles. In addition, the fact that some scientific profiles in scientometric databases are closed has a negative impact on monitoring opportunities.

Increasing migration of people is an important social problem with a wide range of negative consequences, so the authorities of different countries need up-to-date and accurate information about migrants. Sources of data, with mandatory compliance with ethical requirements, can be the use of mobile phones and applications, social networks, databases, etc. (*Salah et al., 2022*). The need to create a methodology for evaluating research activity in the conditions of the diversity of migration processes, based on the monitoring of researchers, is confirmed by the works of H. Moed, M. Aisati, A. Plume (*2013*), who, in particular, noted that establishing connections between authors and author profiles is valuable and a decisive tool in the study of scientific migration.

Analysis of the functionality of Western and Ukrainian bibliometric and scientometric databases regarding the ability to monitor affiliation changes of scientists demonstrates the significant advantages of ORCID as a source database due to its integration with most of the world's scientometric databases. The place of altmetrics in studies of this kind is considered promising, since altmetrics more quickly record rapid changes, but it needs further clarification.

The general approach to recording and evaluating the phenomenon of scientific migration of Ukrainian scientists by national bibliometric systems is considered by us to be such that it should combine a quantitative scientometric approach with expert conclusions. In our opinion, the creation of a special customizable search filter will play a key role in monitoring intelligent migration processes. Among its components should be references to personal identifiers of the scientist (author profiles), a list of scientific institutions and scientometric information systems. Some researchers advise to start using artificial intelligence to solve similar issues, this approach is also considered by us to be one of the promising ones, but it requires a significant material and technical base, which is currently difficult to implement in Ukraine under conditions of limited funding.

The proposed approach to recording and evaluating the phenomenon of scientific migration of Ukrainian scientists using bibliometric systems involves the creation of a concept for monitoring and consolidating data about Ukrainian scientists listed in their personal profiles on such scientometric systems as Google Scholar, Scopus, Web of Science and multidisciplinary register ORCID, where there is information about researchers (their scientific activities, personal data) and research relationships are noted.

The organization of the monitoring system of personal research profiles from the leading scientometric platforms presented in the study is one of the ways to solve the task of updating information on migration processes, which tend to constant changes.

Conclusion

The conducted studies established that the phenomenon of scientific migration is constantly present in all periods of Ukraine's existence. The current state of scientific migration processes in Ukraine is characterized by a sharp surge in migration processes. Scientific migration is associated with the decline of the country's intellectual potential, in particular, the deterioration of scientometric indicators of Ukrainian science.

When analyzing the functional capabilities of bibliographic and scientometric databases regarding the monitoring of affiliates changes of scientists revealed the advantages of the multidisciplinary ORCID registry as a source base for conducting scientometric studies of migration processes.

The proposed concept of a general approach for recording and evaluating the scientific migration of scientists by national bibliometric systems should include a combination of a quantitative scientometric approach with expert conclusions.

For the implementation of the proposed technology for monitoring intellectual migration processes, the information contained in the personal profiles of scientists is of fundamental importance. The availability of such information constitutes a source base for the formation of resources of bibliometric systems that would be able to calculate the activities of Ukrainian scientists abroad.

The presence of positive consequences of intellectual migration is noted: the implementation of scientific research in the conditions of migration, which could not be implemented in Ukraine, the growth of the prestige of Ukrainian science and its demand. Further evaluation of this effect requires additional research. Intellectual migration has a cumulative effect for the development of science in general. The efforts spent on the training of researchers and the formation of scientific schools in one country will find their development in other states.

In the future, the focus should be on the creation of software and analytical tools that will provide a holistic view of the research of scientists who emigrated.

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Наукометричне дослідження міграційних хвиль українських вчених на початку XXI ст.

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Стаття містить результати наукометричного оцінювання сучасного стану наукових міграційних процесів в Україні. Виявлено їх особливості та основні тенденції, сформовано методичні підходи до їхньої фіксації та консолідації отриманих даних у національних бібліометричних системах з використанням методів джерелознавства та аналізу наукових публікацій з досліджуваної теми, а також методів статистичного, порівняльного та структурного аналізу. Джерелами даних для дослідження стали міжнародні мультипредметні бази наукових публікацій Web of Science, Scopus, а також мультидисплінарний реєстратор унікальних наукових ідентифікаторів ORCID, показник Scopus SCImago Journal & Country Rank (для оцінювання наукової ваги публікацій) та інформаційно-аналітична система «Бібліометрика української науки». Авторами встановлено, що явище наукової міграції постійно присутнє в усі періоди існування України і одним з її наслідків є зниження інтелектуального потенціалу країни, марковане погіршенням наукометричних показників діяльності вітчизняної науки. Водночас зафіксовано й позитивні наслідки інтелектуальної міграції, зокрема проведення в умовах еміграції наукових досліджень, які не могли бути реалізовані на батьківщині вченого, зростання відомості українських науковців та їх затребуваності, стимуляція розвитку науки загалом. При проведенні аналізу функціональності бібліометричних та наукометричних баз даних для моніторингу змін афіліацій вітчизняних науковців виявлено переваги реєстру ORCID як вихідної бази даних для проведення наукометричних досліджень міграційних процесів. Запропонована концепція загального підходу до фіксації та оцінки явища наукової міграції вітчизняних науковців національними бібліометричними системами, що має передбачати поєднання цитатно-нумерологічного наукометричного підходу з експертними висновками.

Ключові слова: наукова міграція, бібліометричні та наукометричні дослідження, бібліометричні технології, міграційні процеси в Україні.

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